

## A new species of the *griseifrons* species-group of *Simulium* (*Simulium*) (Diptera: Simuliidae) in northern Thailand

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**Abstract:** A new simuliid species, *Simulium* (*Simulium*) *visuti* sp. nov., is described on the basis of the females, males, pupae and mature larvae collected from northern Thailand. This new species is assigned to the *griseifrons* species-group of the subgenus *Simulium* (*Simulium*), and is characterized by the haired basal portion of the radial vein of the wings not only in the female but also in the male adults. Morphological characteristics differing from those of four related known species are noted.

**Key words:** black fly, Simuliidae, *Simulium*, Thailand, new species, *griseifrons* species-group

In Thailand, the *griseifrons* species-group of the subgenus *Simulium* (*Simulium*) Latreille s. str. is represented by 13 species (Takaoka and Choochote, 2004a, b, 2005a, b). During recent surveys on the immature stages of black flies in Nan Province, northern Thailand, we collected one more species, which is assigned to this species-group by having the simple female claws, the male style with a prominent basal protuberance, the male ventral plate without toothed margins, the pupal gill with six filaments on each side, and the triangular larval postgenal cleft.

This is here described as a new species on the basis of adults (reared from pupae), pupae and mature larvae.

The terms for morphological features used here follow those of Takaoka (2003). Holotype and paratype specimens of the new species are deposited at the Department of Infectious Disease Control, Faculty of Medicine, Oita University, Oita, Japan.

### *Simulium* (*Simulium*) *visuti* sp. nov.

**DESCRIPTION. Female.** Body length 3.4 mm. **Head.** Narrower than width of thorax. Frons brownish-black to black, shiny, (bluish iridescent when illuminated at certain angle of light), widely bare except several dark stout hairs along each lateral margin and a few hairs near lower margin; frontal ratio 1.4 : 1.0 : 1.6; frons-head ratio 1.0 : 4.4. Fronto-ocular area (Fig. 1A) moderately developed, triangular in shape. Clypeus black, thickly white pruinose, slightly shiny when illuminated at certain angle of light, moderately covered with dark stout hairs interspersed with pale fine hairs except median portion of upper 3/5 bare longitudinally. Labrum 0.58 times as long as clypeus. Antenna composed of 2 + 9 segments, medium to dark brown except scape, pedicel, and most of 1st flagellar segment yellow when viewed ventrally or anteriorly (though apical 1/2 of 1st flagellar segment dark brown when viewed dorsally or posteriorly); 1st flagellar segment elongate, 2.1 times as long as 2nd one. Maxillary palp dark brown, composed of 5 segments with proportional lengths of 3rd, 4th, and 5th segments 1.0 : 1.1 : 2.4; 3rd segment (Fig. 1B) of moderate size; sensory vesicle

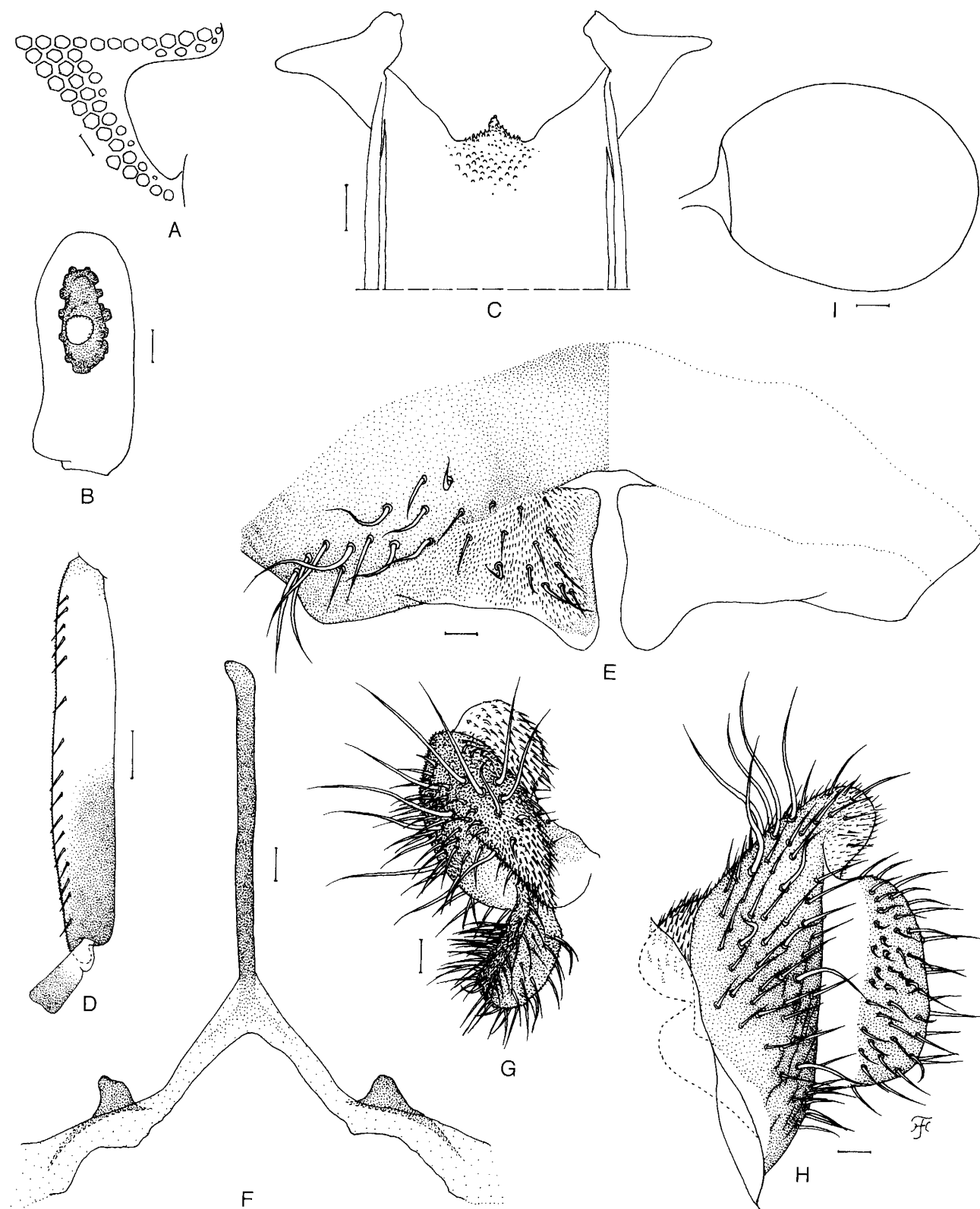
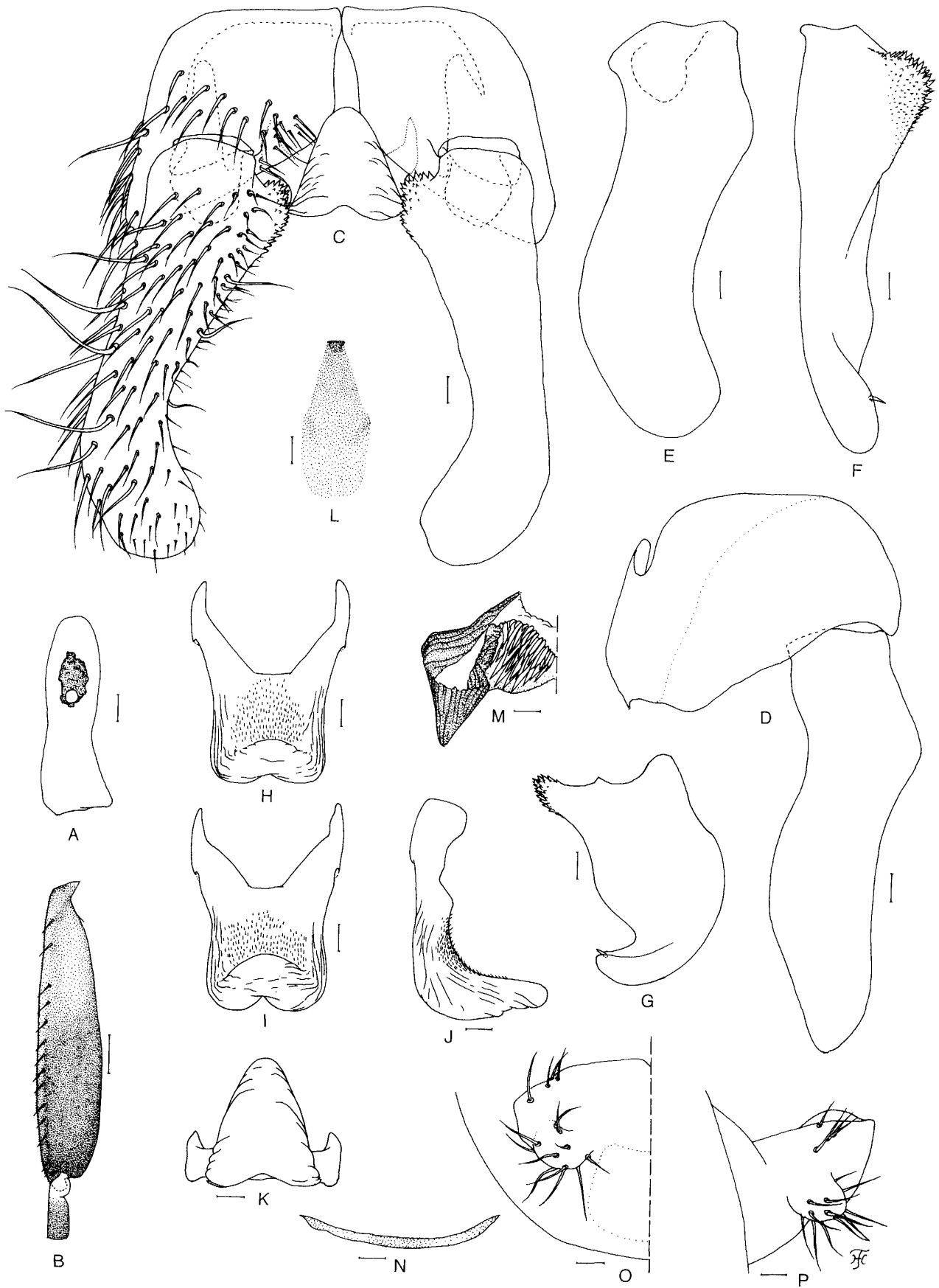


Fig. 1. Female of *Simulium* (*Simulium*) *visuti* sp. nov. A, fronto-ocular area (right side); B, 3rd segment of maxillary palp with sensory vesicle (right side, front view); C, cibarium; D, basitarsus and 2nd tarsal segment of hind leg (left side, outer view); E, 8th sternite and ovipositor valves *in situ* (ventral view); F, genital fork (ventral view); G and H, paraprocts and cerci (right side; G, ventral view; H, lateral view); I, spermatheca. Scale bars. 0.1 mm for D; 0.02 mm for A-C and E-I.

ellipsoidal, 0.40 (right side) or 0.45 times (left side) as long as 3rd segment, with medium-sized round opening medially. Maxillary lacinia with 13 or 14 inner and 16 outer teeth. Mandible with 36 inner and 12 or 13 outer teeth. Cibarium (Fig. 1C) produced medially at its posterior margin into pharynx as triangular projection, and with many minute tubercles on this projection and near its base. **Thorax.** Scutum brownish-black, shiny, densely covered with yellow recumbent fine hairs interspersed with dark long upstanding hairs on prescutellar area; scutum with distinct pattern formed by whitish-grey pruinose and non-pruinose areas, i.e., scutum whitish-grey pruinose with 5 dark longitudinal non-pruinose vittae (i.e., 1 narrow median, 2 rather broad submedian and 2 rather broad lateral vittae), all united on prescutellar area when illuminated anterodorsally and viewed dorsally, and this color pattern reversed when illuminated posteriorly and viewed dorsally. Scutellum ocherous to light brown, shiny, with long dark marginal hairs as well as yellow recumbent short hairs. Postnotum dark brown except central portion light brown, shiny, without hairs. Pleural membrane bare. Katepisternum longer than deep, and bare. **Legs.** Foreleg: coxa yellowish-white; trochanter light brown except anterior surface narrowly yellow and basal 1/2 of posterior surface yellow; femur dark yellow (though inner surface yellow), with apical cap medium brown; tibia light to medium brown on basal 3/5 except outer surface widely yellowish-white and white sheeny when illuminated at certain angle of light, and brownish-black to black on apical 2/5; tarsus entirely black; basitarsus, 2nd and 3rd tarsal segments with weakly developed dorsal hair crest; basitarsus moderately dilated, 6.4 times as long as its greatest width. Midleg: coxa dark brown; trochanter medium brown except basal 1/2 yellow; femur dark yellow except base yellow (though inner surface widely yellow), with apical cap medium brown; tibia yellow except a little more than apical 2/5 dark brown to black; tarsus brownish-black except basal 2/5 of basitarsus dark yellow though its border not well defined. Hind leg: coxa brown; trochanter yellow; femur dark yellow except basal 1/4 clear yellow (though inner surface widely yellow) and apical cap dark brown; tibia yellow except a little more than apical 2/5 brownish-

black to black; tarsus brownish-black except a little more than basal 1/2 of basitarsus and basal 1/2 of 2nd tarsal segment yellow; basitarsus (Fig. 1D) nearly parallel-sided, 6.5 times as long as wide, 0.77 and 0.71 times as wide as hind tibia and femur, respectively; calcipala distinct, nearly as long as wide; pedisulcus distinct. All tarsal claws simple, without subbasal or basal tooth. **Wing.** Length 3.0 mm. Costa with spinules and hairs. Subcosta haired except near apex bare. Basal section of vein R fully haired; R<sub>1</sub> with dark spinules and hairs; R<sub>2</sub> with dark hairs. Hair tuft at base of stem vein dark brown. Basal cell absent. **Abdomen.** Basal scale ocherous, with fringe of dark long hairs; dorsal surface of 2nd segment blackish-brown except anterior 1/2 or a little more (corresponding to tergite) whitish-yellow to light ocherous having pair of large dorsolateral whitish spots broadly connected to each other in middle; dorsal surface of other segments blackish-brown except tergites 3–5 light ocherous, tergites 6–8 partially light ocherous and narrow intersegmental areas from segment 2 to segment 8 transversely light ocherous; tergites 3–5 small, tergites 6–8 large, white pruinose and shiny when illuminated at certain angle of light; all segments moderately covered with dark short hairs. Ventral surface of abdomen ocherous to light brown except paraprocts and cerci dark brown, with short hairs; segment 7 with large nearly quadrate sternal plate medially. **Genitalia.** Sternite 8 (Fig. 1E) moderately sclerotized, bare medially but with 14–16 short to very long stout hairs on each side; ovipositor valves (Fig. 1E) somewhat produced posteriorly, with round posteromedial corner, membranous and nearly transparent except narrow area along inner margin and small subapical area of posteromedial corner weakly sclerotized, covered with 8 or 9 short to medium-long pale hairs and 3 dark medium-long stout hairs as well as numerous microsetae except narrow areas along inner and posterior margins bare; inner margins slightly concave medially, moderately separated from each other. Genital fork (Fig. 1F) of inverted-Y form, with well sclerotized stem; arms slender, with sclerotized apical bulge having short stout projection directed anteriorly. Paraproct in ventral view (Fig. 1G) with deep concavity on anteroventral surface, covered with about 60 medium-long to very long stout hairs (several very long hairs are



longer than those on sternite 8) as well as numerous microsetae; anteromedial surface of paraproct moderately sclerotized, with 10 or 11 sensilla; paraproct in lateral view (Fig. 1H) much wider than long, produced ventrally beyond level of ventral end of cercus. Cercus in ventral view (Fig. 1G) moderately curved outwardly; cercus in lateral view (Fig. 1H) rectangular, about half as long as wide, covered with many short to medium-long hairs. Spermatheca (Fig. 1I) ellipsoidal, well sclerotized, with reticulate pattern near base, and with minute internal setae; area around junction to duct unsclerotized; accessory ducts subequal in diameter to each other, and also to major one.

**Male.** Body length 3.2–3.6 mm. **Head.** Width as wide as thorax. Upper eye consisting of large facets in 20 vertical columns and in 20 or 21 horizontal rows; large facets clear vermilion and small ordinary ones dark brown. Clypeus brownish-black, white pruinose, moderately covered with dark long stout hairs except median portion widely bare longitudinally. Antenna composed of 2+9 segments, medium to dark brown except base of pedicel and base of 1st flagellar segment dark yellow when viewed posteriorly or dorsally, or medium to dark brown except scape, pedicel and basal 1/2 or a little more of 1st flagellar segment dark yellow when viewed anteriorly or ventrally; 1st flagellar segment elongate, 2.0–2.2 times as long as 2nd one. Maxillary palp composed of 5 segments, with its proportional lengths from 3rd to 5th segments 1.0 : 1.1 : 2.6; 3rd segment (Fig. 2A) of normal size; sensory vesicle oblong, 0.28 times as long as 3rd segment, with opening of medium size. **Thorax.** Scutum black, uniformly and densely covered with golden-yellow recumbent fine hairs interspersed with long upright hairs on prescutellar area; scutum with large white-pruinose spot on each shoulder, extending posteriorly forming broad white-pruinose band along each lateral margin up to base of wing; at certain angle of

light, large white-pruinose spot present on pre-scutellar area. Scutellum brownish-black, with several dark upright long hairs as well as golden-yellow fine short hairs. Postnotum brownish-black, slightly shiny, white pruinose at certain angle of light, and without hairs. Pleural membrane and katapisternum as in female. **Legs.** Foreleg: coxa yellowish-white; trochanter medium brown except base yellow; femur medium brown except apical cap dark brown; tibia and tarsus entirely brownish-black; tarsus slightly dilated, with moderate dorsal hair crest; basitarsus 6.7 times as long as its greatest width. Midleg: coxa brownish-black; trochanter medium brown except basal 1/2 yellow; femur medium brown except apical cap dark brown; tibia medium to dark brown except extreme base yellowish-white, and with subbasal area somewhat lighter on anterior surface; tarsus medium to dark brown. Hind leg: coxa brownish-black; trochanter clear yellow basally and dark yellow to light brown apically; femur medium to dark brown except a little less than basal 1/4 yellow and apical cap brownish-black; tibia brownish-black except extreme base yellowish-white; tarsus brownish-black except basal 2/5 or a little more of basitarsus medium to dark brown, and basal 1/3 of 2nd segment yellowish-white; basitarsus (Fig. 2B) somewhat enlarged, slightly widened from base to apical 1/3, then slightly narrowed toward apex, 4.44 times as long as its greatest width, 0.90 and 0.96 times as wide as hind tibia and femur, respectively. Calcipala small, slightly shorter than width at base. Pedisulcus well marked. **Wing.** Length 2.6–2.9 mm. Other characters (including the haired basal portion of radial vein) as in female except subcosta bare in 1 male and with 2 or 3 hairs in other male. **Abdomen.** Basal scale brownish-black with fringe of long dark hairs. Dorsal surface brownish-black except anterior 2/3 of 2nd segment light to medium brown, and with dark and light short hairs; segments 2 and 5–7 each with pair of large whitish-grey pruinose spots

Fig. 2. Male of *Simulium* (*Simulium*) *visuti* sp. nov. A, 3rd segment of maxillary palp with sensory vesicle (right side, front view); B, basitarsus and 2nd tarsal segment of hind leg (left side, outer view); C, coxites, styles and ventral plate *in situ* (ventral view); D, coxite and style (right side, lateral view); E–G, styles (E and F, right side; G, left side; E, ventrolateral view; F, medial view; G, end view); H–K, ventral plates (H and I, anteroventral view; J, lateral view; K, ventroposterior view); L, median sclerite (ventroposterior view); M, paramere (right side, end view); N, dorsal plate; O and P, 10th abdominal segments with cercus (right side; O, end view; P, lateral view). Scale bars. 0.1 mm for B; 0.02 mm for A and C–P.

(those on segments 2, 5 and 6 situated dorsolaterally, while those on segment 7 almost laterally). **Genitalia.** Coxite in ventral view (Fig. 2C) nearly quadrate, but in lateral view (Fig. 2D) about 0.6 times as long as wide. Style in ventral view (Fig. 2C) gradually narrowed from base to apical  $1/3$ , then nearly parallel-sided, with rounded apex having no or slender subapical spine; style in lateral view (Fig. 2D) elongate, about 2.4 times as long as coxite; style in ventrolateral view (Fig. 2E) roughly S-shaped, 3.1 times as long as greatest width at base, very slightly narrowed from somewhat swollen subbasal portion to middle, then slightly widened to apical  $1/4$ , and slightly narrowed toward apex (narrow portion of middle about 0.78 times as wide as width at base); style in medial and end views (Fig. 2F, G) with short basal protuberance directed dorso-medially having many cone-shaped spines on and near outer margin. Ventral plate in anteroventral view (Fig. 2H, I) with body nearly quadrate or slightly longer than wide, moderately covered with minute setae on ventral surface, and having distinct ventrally-produced process posteriorly, which is covered with minute setae centrally on anterior surface (except near ventral tip bare), but bare on its apex and posterior surface; basal arms stout basally, 0.36–0.43 times as wide as breadth of body, and diverged basally, then nearly parallel-sided near apex, with inner margins close basally to each other making about right angle between them; ventral plate in lateral view (Fig. 2J) with ventrally-produced process at right angle to body, with several furrows on each side of body and process; ventral plate in ventroposterior view (Fig. 2K) with triangular ventrally-produced process having several furrows on each side and without setae. Median sclerite in ventroposterior view (Fig. 2L) long, plate-like, narrow basally, gradually widened toward apex, and moderately sclerotized except median portion of apex weakly sclerotized; median sclerite in lateral view with basal tip arising slightly beyond anterior margin of body of ventral plate, running posteriorly, then abruptly bent dorsally at basal  $1/3$ . Paramere (Fig. 2M) broad basally, with several hooks apically. Aedeagal membrane densely setose; dorsal plate (Fig. 2N) weakly sclerotized. Abdominal segment 10 (Fig. 2O, P) with 1–4 short hairs on each posterolateral surface. Cerci (Fig. 2O, P) rounded,

each with 11–15 short hairs.

**Pupa.** Body length about 4.0 mm. **Head.** Integument dark yellow to yellowish-brown, densely covered with tubercles of different sizes on its entire surface including antennal sheaths (Fig. 3A); most of tubercles on frons somewhat larger than others on face and antennal sheaths, and with several minute projections on its surface (Fig. 3B); frons on each side with 2 long trichomes situated close together, each with 3 or 4 long branches (Fig. 3A); face with 1 very long trichome with 4 or 5 long branches (Fig. 3A) on each side. **Thorax.** Integument dark yellow to yellowish-brown, densely covered with tubercles all over; relatively larger tubercles on anterior surface with minute secondary projections on its surface similar to those on frons; integument on each side with 4 very long fan-like trichomes, each with 6–10 long branches (Fig. 3C) anterodorsally, 1 long trichome with 2–6 branches (Fig. 3D) posterolaterally, and 3 long trichomes (each with 2–6 branches) (Fig. 3E–G) ventrolaterally. Gill (Fig. 3H) with 6 thread-like short filaments arranged in 3 pairs, all arising from base and almost sessile though dorsal and ventral pairs of filaments appearing very short-stalked; all filaments dark brown, diverged vertically with uppermost filament at angle of 110–150 degrees to lowermost filament, subequal in length (1.1–1.4 mm long) and thickness to one another, nearly parallel-sided along basal  $2/5$  (though uppermost filament somewhat constricted basally), then gradually tapered toward apex; cuticle of all filaments with well-marked annular ridges and furrows, ridges elaborately forming reticulate patterns and densely covered with minute tubercles, somewhat larger ones on ridges and smaller ones on interridge spaces. **Abdomen.** Dorsally segment 1 yellow, weakly sclerotized, with 1 bifid medium-long seta on each side; segment 2 pale, with 1 simple medium-long seta and 5 short spines submedially on each side; segments 3 and 4 each with 4 hooked spines and 1 simple spine on each side; segments 5–7 and 9 lacking spine-combs; segment 8 with well developed spine-combs in transverse row on each side; segments 7–9 each with comb-like groups of minute spines in transverse rows on each side; segment 9 with pair of small terminal hooks and with or without several small tubercles between terminal hooks (Fig. 3I). Ventrally, segment 4 with 1 simple hooklet and

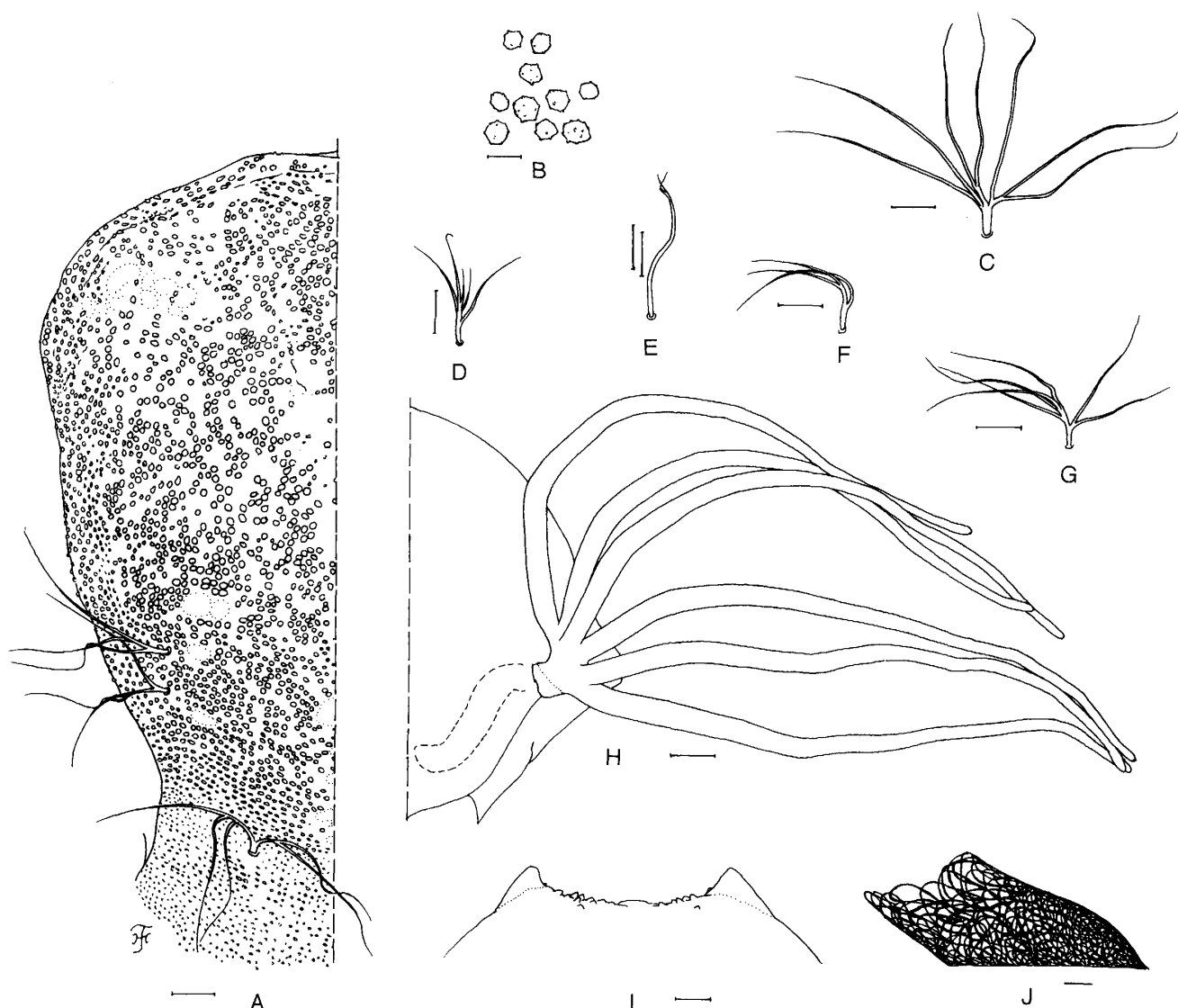


Fig. 3. Pupa of *Simulium* (*Simulium*) *visuti* sp. nov. A, frons and part of face with 2 frontal and 1 facial trichomes (right half); B, tubercles with secondary projections on frons; C–G, trichomes on thorax (C, anterodorsal; D, posterolateral; E–G, ventrolateral); H, gill filaments (right side, lateral view); I, terminal hooks and tubercles on 9th abdominal segment (dorsal view); J, cocoon (lateral view). Scale bars. 0.5 mm for J; 0.1 mm for H; 0.05 mm for A and C–G; 0.02 mm for I; 0.01 mm for B.

a few medium-long spinous setae on each side; segment 5 with pair of simple hooks sub-medially and a few simple medium-long spinous setae on each side; segments 6 and 7 each with pair of simple inner and simple outer hooks somewhat spaced from each other, and a few simple medium-long spinous setae on each side. **Cocoon** (Fig. 3J). Boot-shaped, loosely woven, with many small open spaces in webs; anterior collar variable in height, being 0.6–1.5 mm; individual threads visible; 5.2–5.6 mm long by 1.8–2.3 mm wide.

**Mature larva.** Body length 8.1–9.0 mm. Body characteristic in shape, being gradually widened posteriorly up to abdominal segment

8, and then sharply narrowed to the posterior circlet; dorsal surface of body light brown though anterior 1/2 replaced by or mixed with light to dark greyish color; ventral surface of body dark grey or greyish brown except posterior 1/2 whitish. Cephalic apotome yellow to light yellowish-brown with narrow portion along posterior margin light to dark brown; anterior one of median longitudinal spots usually indistinct and posterior one of the same spots light to medium brown; posterior one of mediolateral spots always dark brown and anterior one light brown; posterolateral spots indistinct or light to medium brown. Lateral surface of head capsule yellow to light

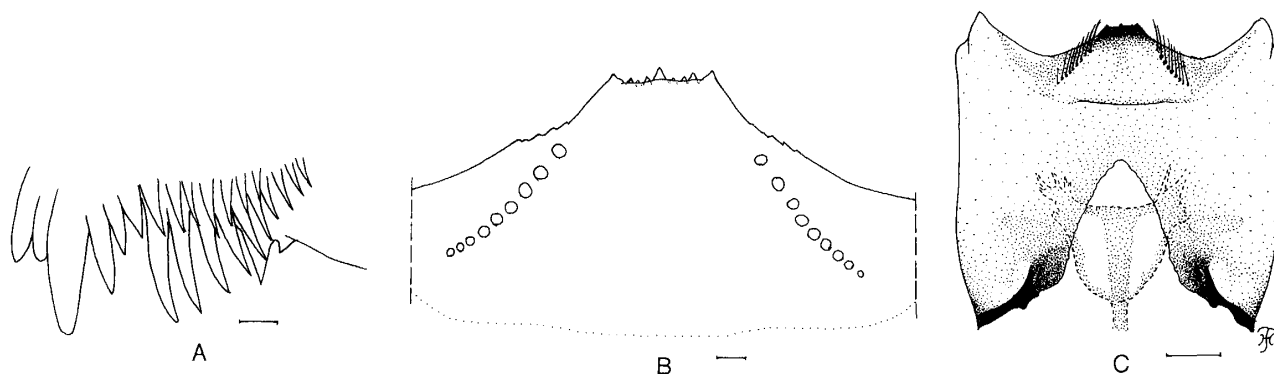


Fig. 4. Mature larva of *Simulium (Simulium) visuti* sp. nov. A, apical portion of mandible; B, hypostoma; C, head capsule showing postgenal cleft and subesophageal ganglion (ventral view). Scale bars. 0.1 mm for C; 0.02 mm for B; 0.01 mm for A.

yellowish-brown except posterodorsal area posterior to eye-spot region light to medium brown; eyebrow moderately defined; dorsal one of spots just before posterior margin usually medium brown and lower one indistinct or light to medium brown; isolated spot below eye-spot region light to medium brown. Ventral surface of head capsule yellow to medium brown, spot on each side of postgenal cleft light to medium brown appearing faintly positive or negative or merged in background color. Antenna composed of 3 segments and apical sensillum, longer than stem of labral fan; proportional lengths of 1st, 2nd, and 3rd segments 1.00 : 1.20–1.26 : 0.49. Labral fan with 48–50 main rays. Mandible (Fig. 4A) with mandibular serrations composed of 1 large tooth and 1 small one; large tooth at obtuse angle with inner margin of mandible on apical side; supernumerary serrations absent; 1st comb-tooth longest, much longer than 2nd tooth, which is slightly longer than 3rd tooth. Hypostoma (Fig. 4B) with 9 anterior teeth, of which median tooth longest of all, followed by corner teeth; lateral margins moderately serrate apically; 9 or 10 hypostomal bristles diverging posteriorly from lateral border on each side. Postgenal cleft (Fig. 4C) deep, triangular, 0.40–0.43 times as long as postgenal bridge; subesophageal ganglion well pigmented at least peripherily and medially. Cervical sclerite composed of 2 light brown small elliptical pieces each just posterior to medial tip of each occiput. Thoracic cuticle almost bare. Abdominal cuticle bare except last segment moderately covered with short colorless setae on each side of anal sclerite. Rectal scales present. Rectal organ compound, with 17–23

finger-like secondary lobules per lobe. Anal sclerite X-shaped, with anterior arms 0.53 times as long as posterior ones; anterior arms broadened and bifurcated apically when viewed laterally; basal juncture area with deep narrow incision posteriorly; several sensilla present just posterior to posterior arms; accessory sclerite absent. Last abdominal segment slightly bulged laterally but lacking ventral papillae. Posterior circlet with 136–138 rows of hooklets with up to 22 hooklets per row.

**TYPE SPECIMENS.** Holotype female with associated pupal exuviae and cocoon, collected in Doi Phu Wae, Thung Chang District, Nan Province, northern Thailand, 16. I. 2006, by W. Choochote. Paratypes: 2 males with associated pupal exuviae and cocoons, 2 pupae, 4 mature larvae, same data as those of the holotype.

**ECOLOGICAL NOTES.** The pupae and larvae of *S. (S.) visuti* sp. nov. were found to be attached to the surface of a stream-bed rock in a moderately running stream (width about 2 m, depth 20–30 cm, exposed to sun, water temperature 15°C, altitude 1,050 m) in a sparsely forested area. This species was collected together with *S. (Gomphostilbia) inthanonense* Takaoka and Suzuki, *S. (G.) decuplum* Takaoka and Davies, and *S. (S.) chamlongi* Takaoka and Suzuki.

**ETYMOLOGY.** The species name *visuti* is in honor of Prof. Visut Baimai, formerly



Head of Department of Biology, Faculty of Science, Mahidol University, from whom WC learned much in biology during his Bachelor of Science course.

REMARKS. *Simulium* (S.) *visuti* sp. nov. is assigned to the *griseifrons* species-group of the subgenus *Simulium* s. str. by the combination of the following characters: the simple female claw, the style much longer than the coxite and with a basal protuberance armed with many spines, the ventral plate without distinct teeth on its posterolateral margins, and the pupal gill with six filaments on each side. It seems to be most closely related to *S.* (S.) *tenuitarsus* Puri, originally described from the male and pupal specimens collected from Bengal Terai, India (Puri, 1933), by having a similar shape of the male genitalia, the haired basal portion of the radial vein, branched trichomes on the head and thorax of the pupa, the gill with six short thread-like filaments, and the boot-shaped cocoon. However, this new species is distinguished from the latter species by the following characters (those of *S.* (S.) *tenuitarsus* in parentheses): the arms of the ventral plate, which are stout basally, 0.36–0.43 times as wide as the breadth of the body of the ventral plate, and are diverged basally, with their inner margins nearly at a right angle (arms slender, 0.28 times as wide as the width of the body of the ventral plate, and are only slightly diverged basally, with their inner margins at an angle of about 45 degrees to each other), trichomes on the head with 3–5 branches (with 7–9 branches), the anterodorsal surface of the thoracic integument on each side with four branched trichomes (with five branched trichomes), and the dorsalmost filament constricted basally (not constricted).

*Simulium* (S.) *visuti* sp. nov. is also similar to *S.* (S.) *choochotei* from Thailand (Takaoka and Choochote, 2002), *S.* (S.) *pukaengense* also from Thailand (Takaoka and Choochote, 2005b) and *S.* (S.) *digrammicum* from Peninsular Malaysia

and Thailand (Edwards, 1928; Takaoka and Choochote, 2002) by having the haired basal portion of the radial vein of the female and male adults. However, *S.* (S.) *choochotei* differs in the female by the presence of numerous very long stout hairs on the ovipositor valves (longer than those on the eighth sternite and on the paraprocts), in the male by the large eye facets in 17 vertical columns and the tenth abdominal segment with 13–16 hairs on each posterolateral corner, and in the pupa by the somewhat inflated gill filaments. *Simulium* (S.) *digrammicum* is different from this new species by the female cibarium with tubercles only on the medial projection, the male ventral plate with its base narrowed posteriorly and the cocoon tightly woven and with a small lateral window on each side. *Simulium* (S.) *pukaengense* is distinguished from *S.* (S.) *visuti* sp. nov. by the cibarium with prominent medial projection, the ventral plate with much narrower body, the six pupal gill filaments decreasing in length and thickness from dorsal to ventral and the boot-shaped cocoon without any open space in the webs.

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